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1.d. Near and Distant Tsunamis

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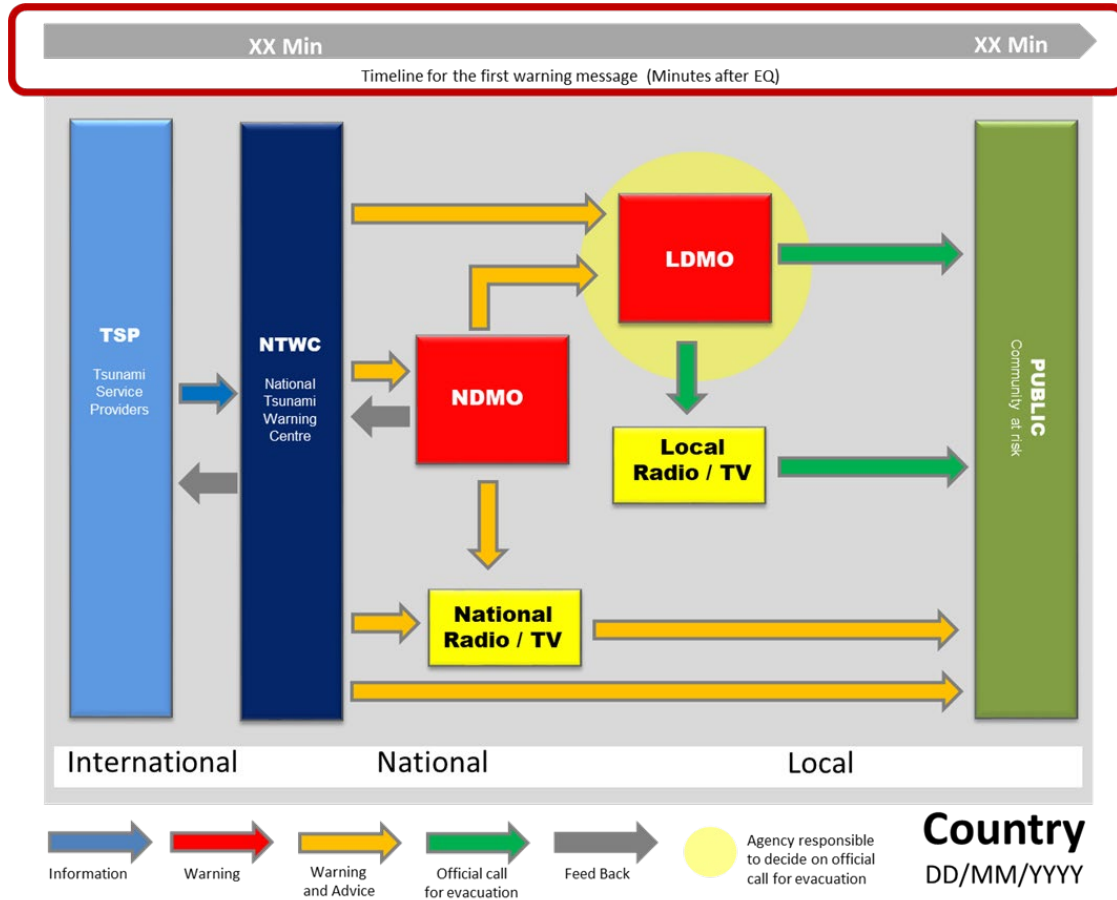
Ardito M Kodijat

IOTIC UNESCO-IOC

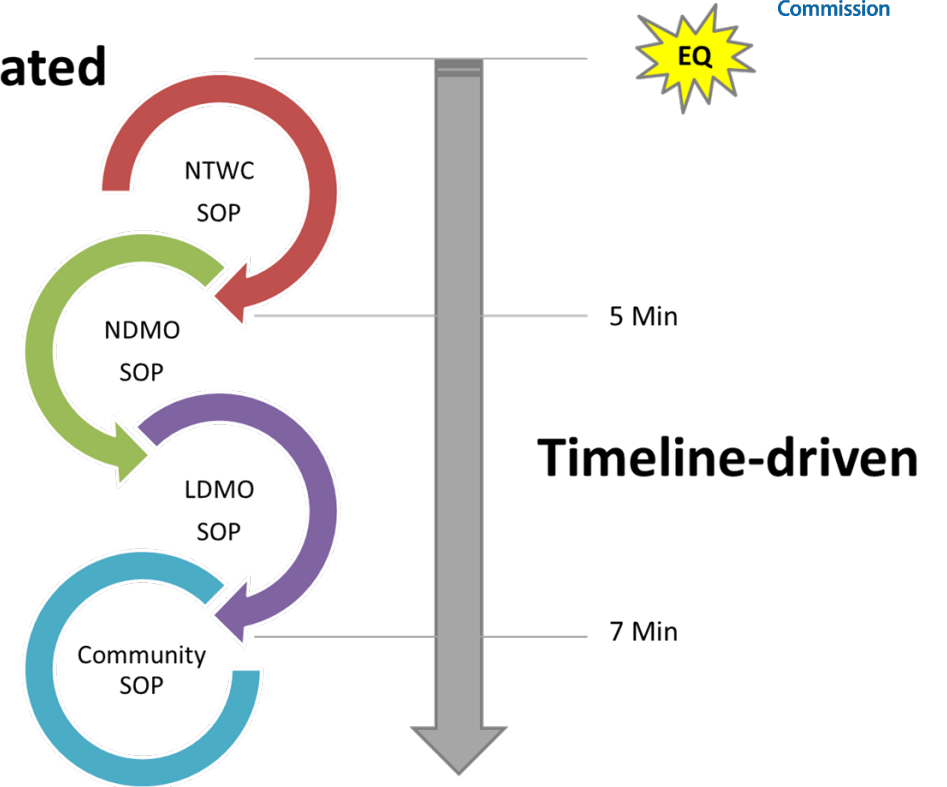
Near and distant tsunamis

TIMELINE DRIVEN SOPS

The timeline provides the framework...



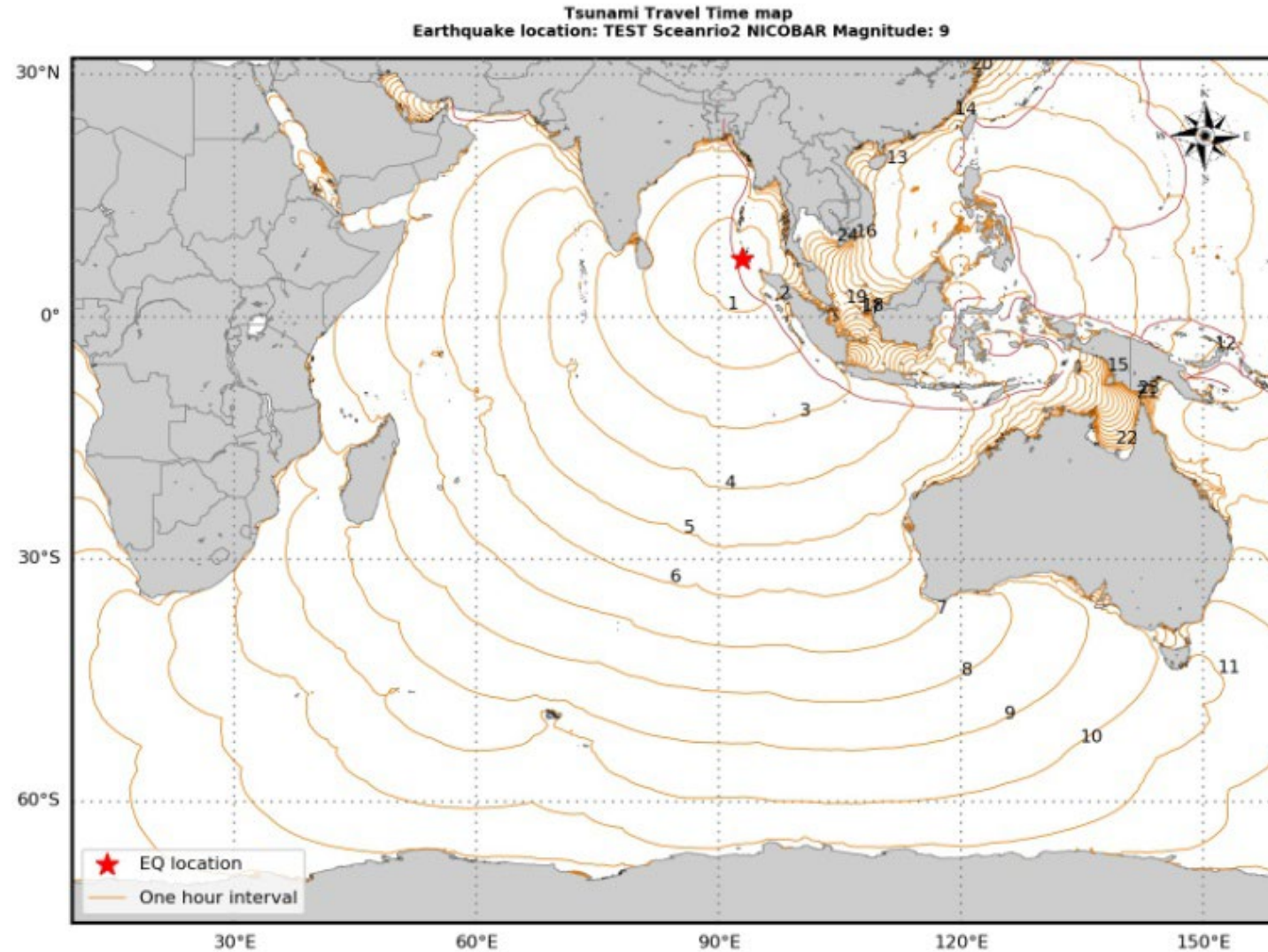
Integrated



...and requires integrated and timeline-driven SOPs

In line with time?

Travel times from Sunda Trench / Nicobar Islands



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Scenario

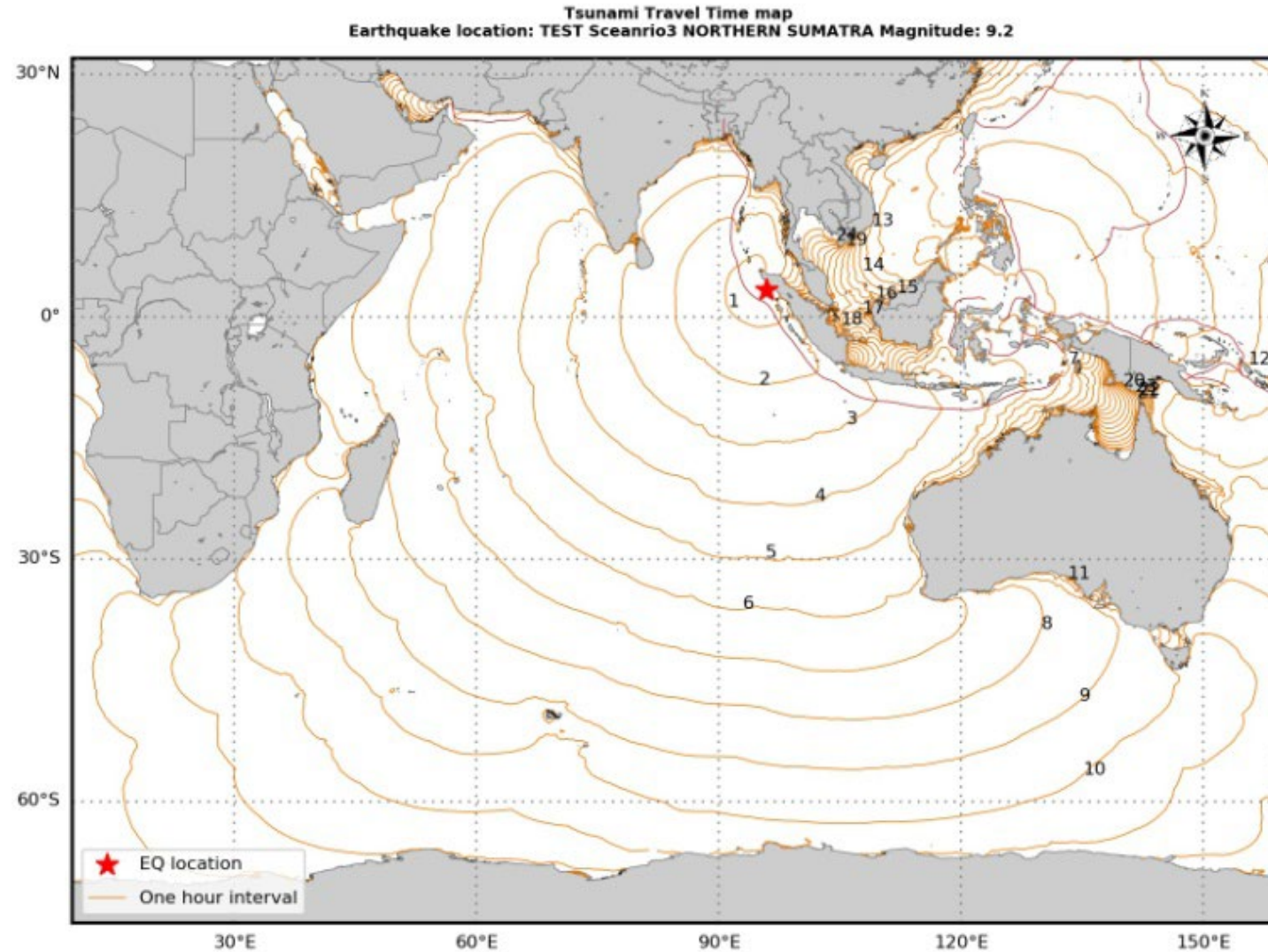
In line with time?

Travel times from Sunda Trench / Northern Sumatra



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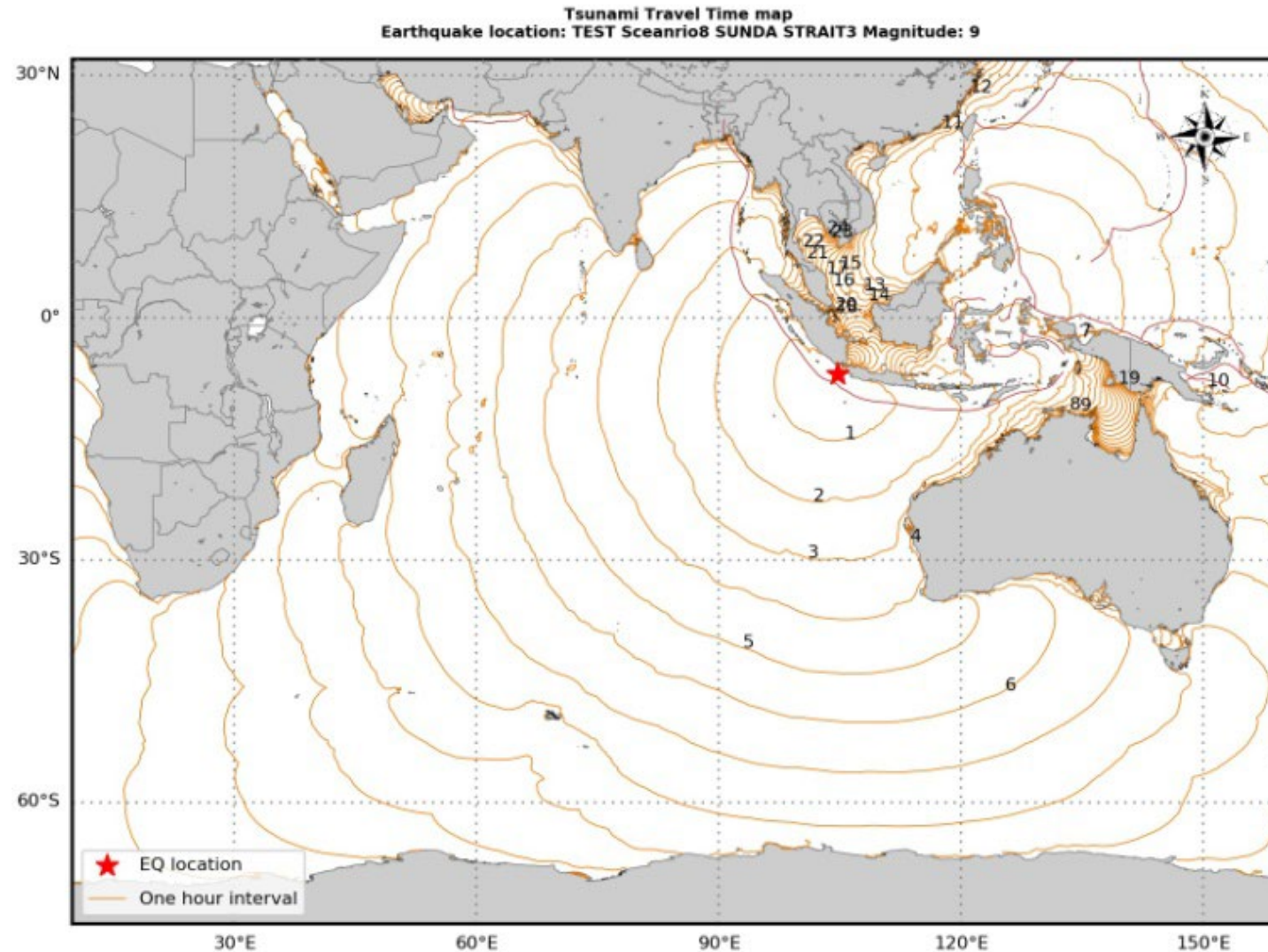


IOWave25
Scenario

Pre-IOWave25 Workshops on Standard Operating Procedures for NTWCs and DMOs
Hybrid – August 2025

In line with time?

Travel times from Sunda Trench / Sunda Strait



IOWave25
Scenario

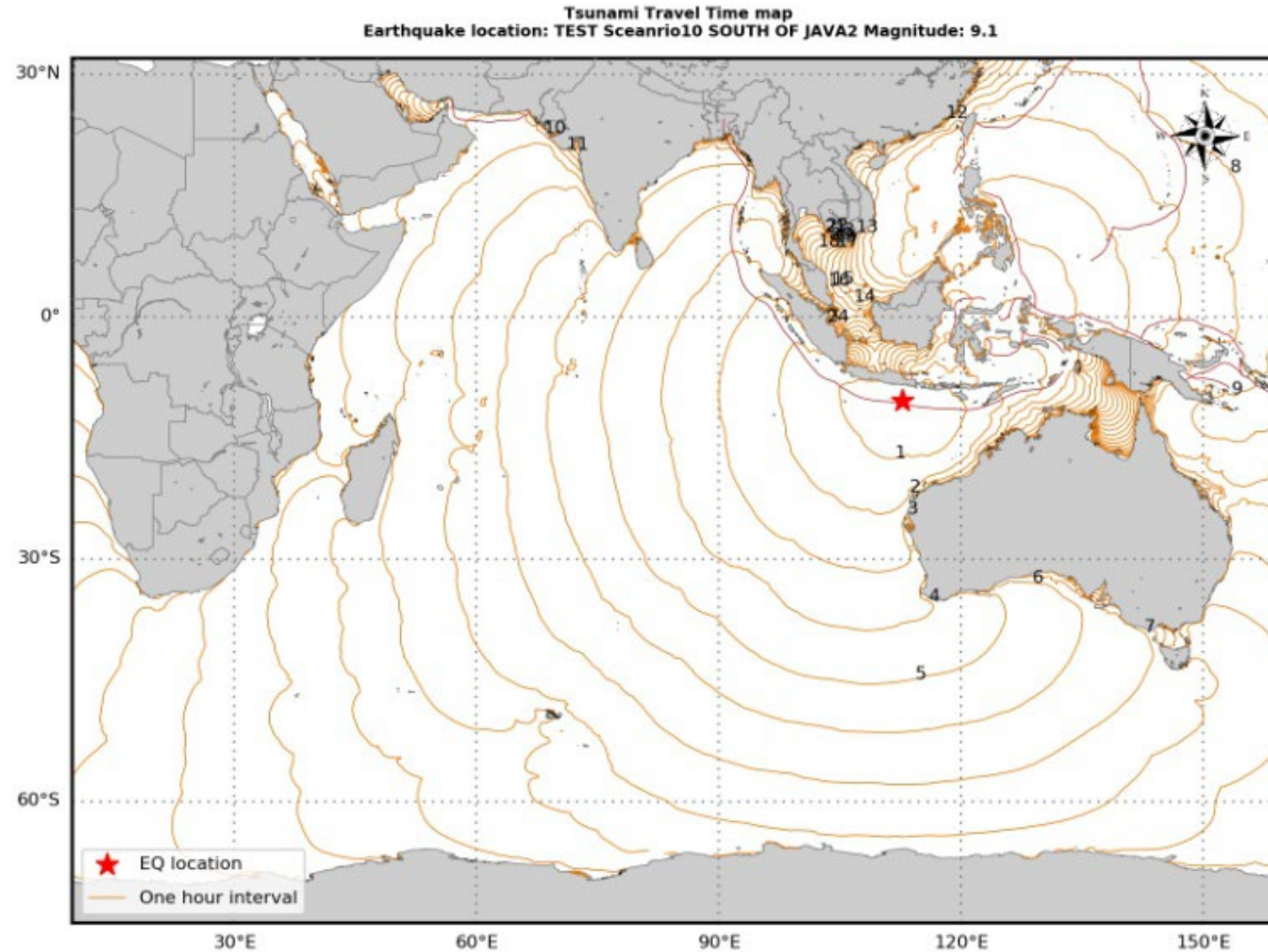
In line with time?

Travel times from Sunda Trench / South of Java



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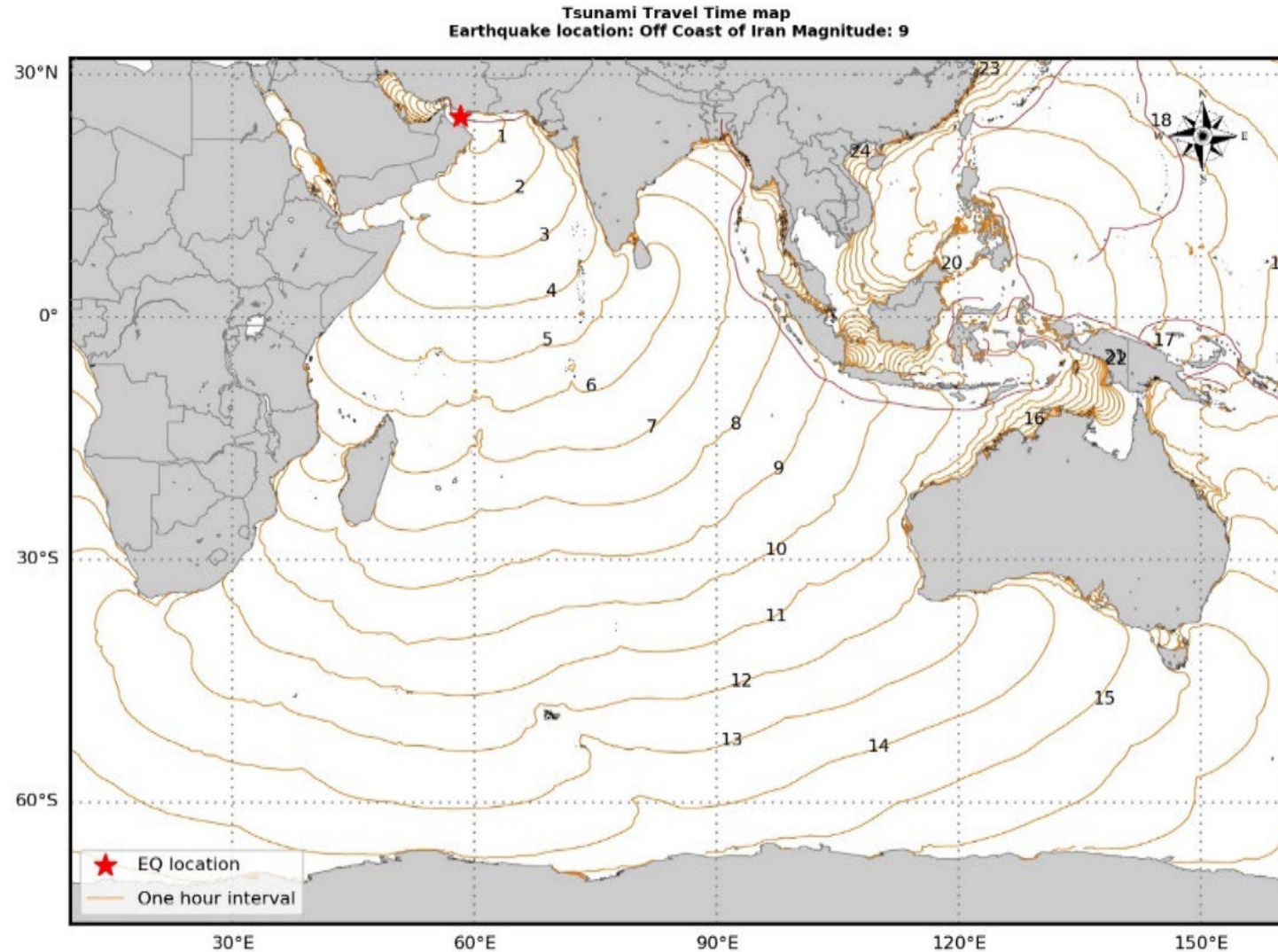


IOWave23
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In line with time?

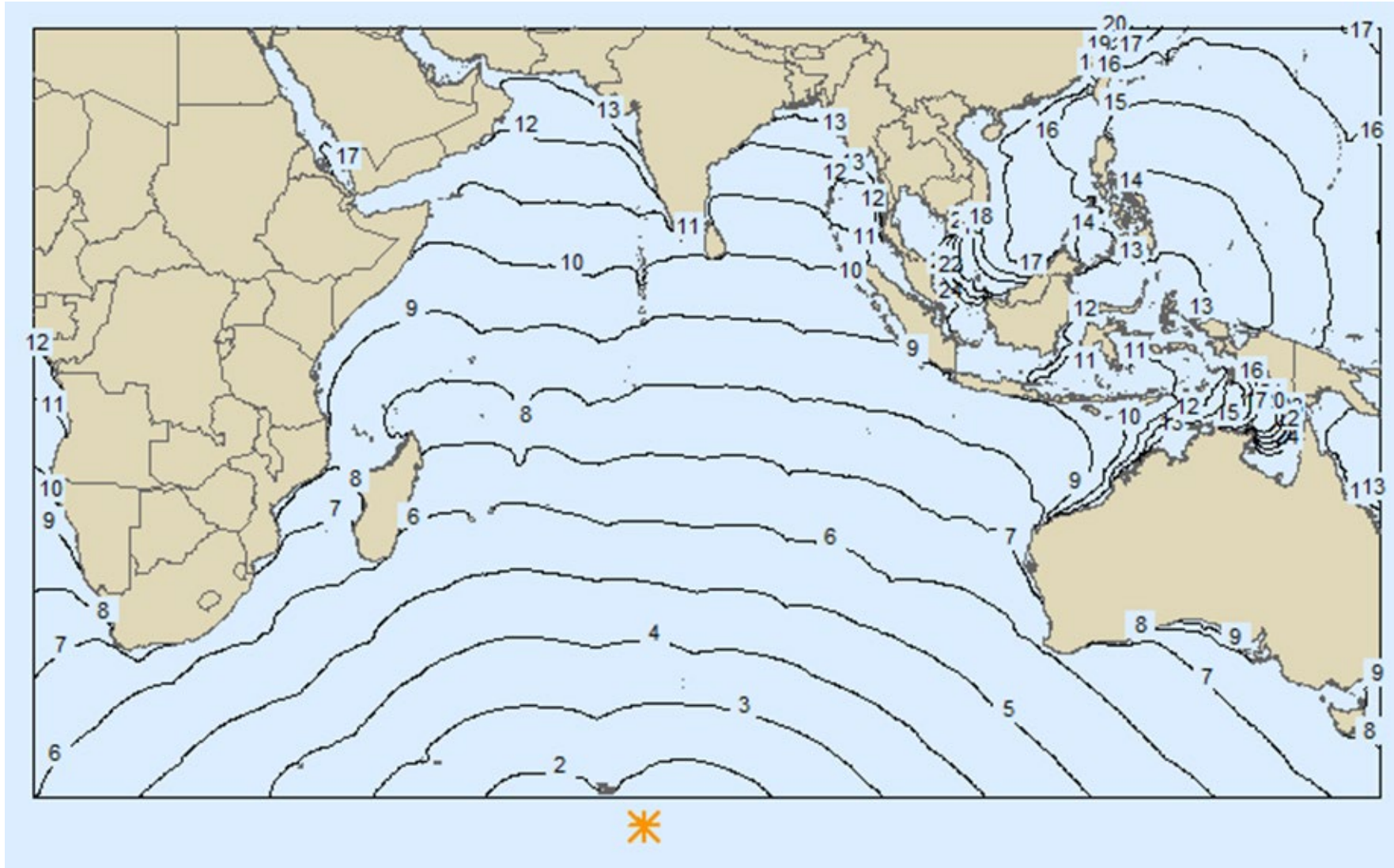
Travel times from Makran Subduction Zone



IOWave23 and 25
Scenarios

In line with time?

Travel times from Heard Island Volcano



IOWave23
Scenario

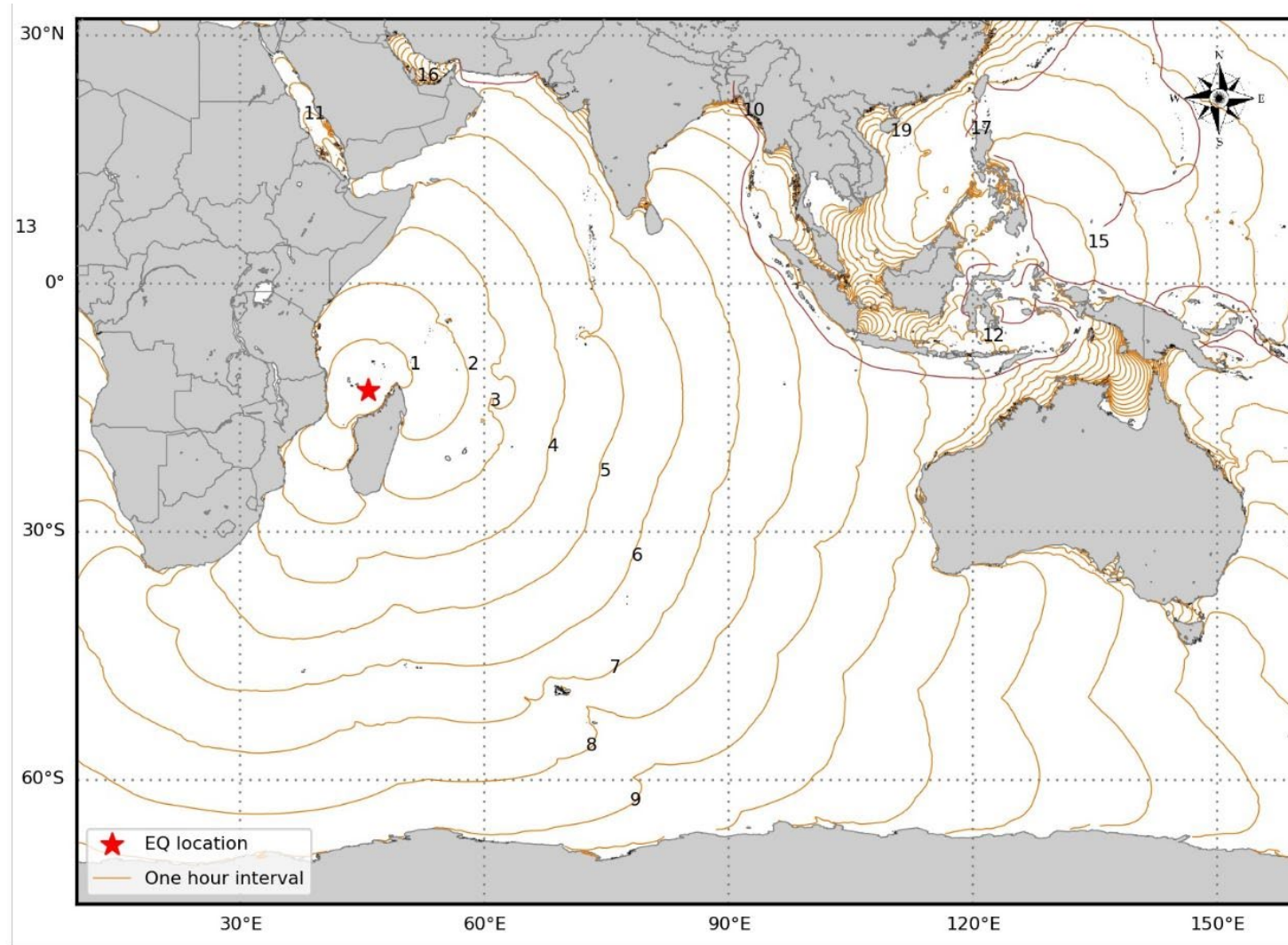
In line with time?

Travel times from Fani Maore Volcano



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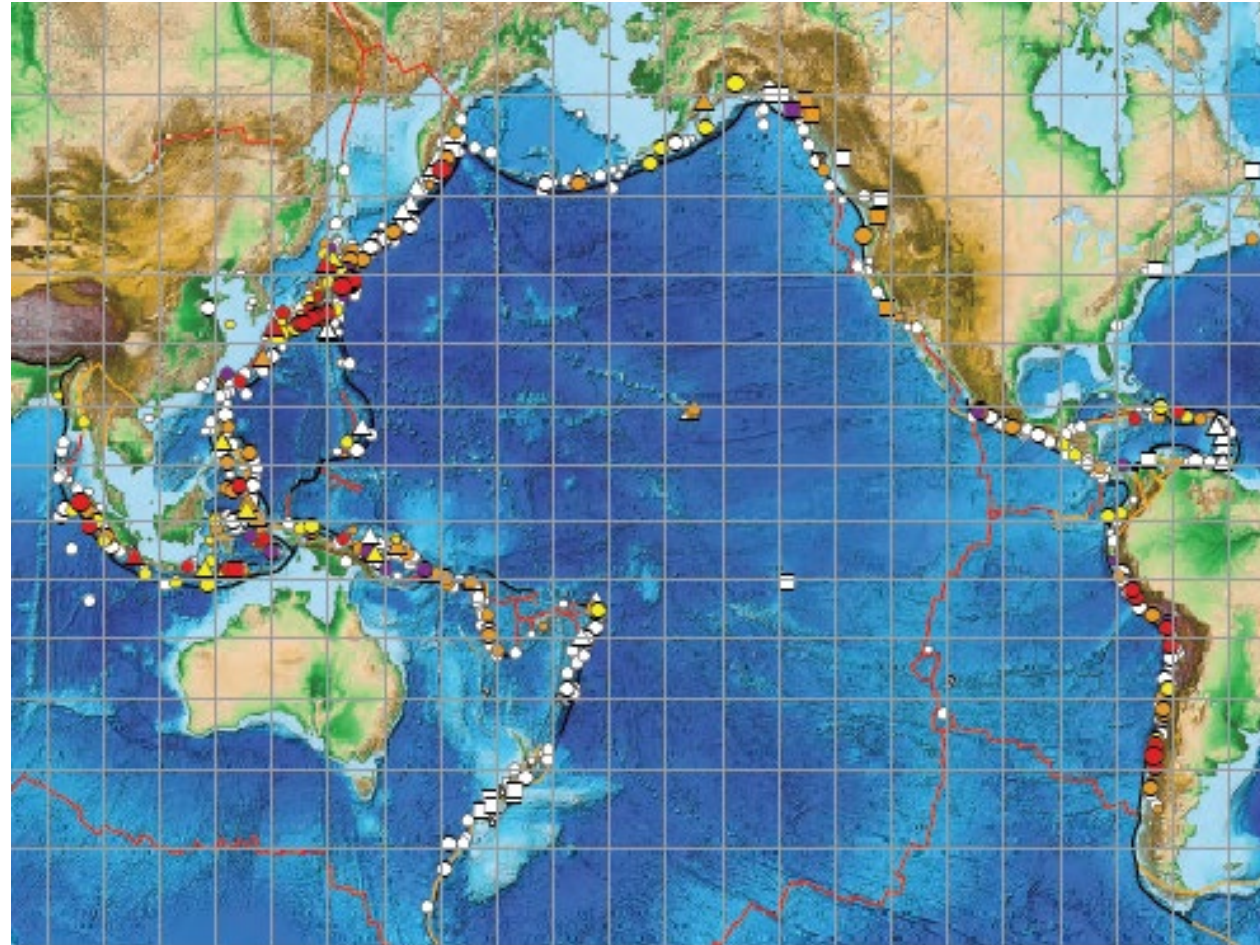


IOWave25
Scenario

Pre-IOWave25 Workshops on Standard Operating Procedures for NTWCs and DMOs
Hybrid – August 2025

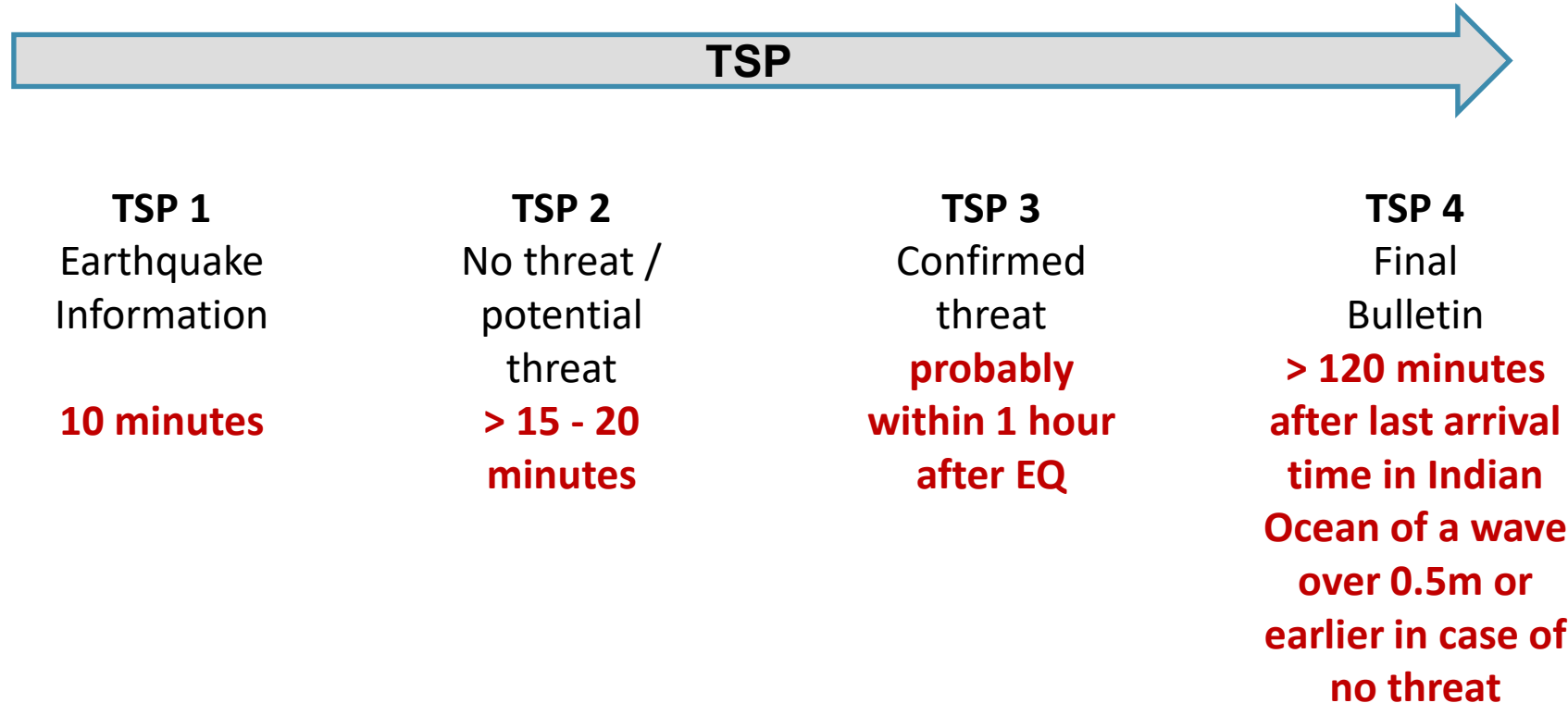
In line with time?

Pacific and Indonesia seas sources to be considered by
Australia, Indonesia, Malaysia, Singapore, Thailand, Timor Leste



In line with time?

TSP Timeline for seismic induced tsunamis



In line with time?

TSP Timeline for volcano induced tsunamis



TSP 2
No threat /
potential
threat
**> 1 - 2 hours
after eruption**

(1 hour in Fani
Maore Sceario
and 2 hours in
Heard Island
Scenario)

TSP 3
Confirmed
threat
**2,5 hours after
eruption
(Heard Island
Scenario)**

TSP 4
Final
Bulletin
**> 120 minutes
after last arrival
time in Indian
Ocean of a wave
over 0.5m or
earlier in case of
no threat**

In line with time?

Timelines for EIO countries

		Threat			
		Near Field	Regional	Far Field	
		ETA < 60 minutes	ETA 60-180 minutes	ETA >180 Minutes	
EIO	Australia	H	S	Pacific	H
	Bangladesh		S		H
	India	S	M	S	H
	Indonesia	S	S	Pacific	H
	Malaysia		S	Pacific	H
	Maldives			M/S	H
	Myanmar	S	S		H
	Singapore		S	Pacific	
	Sri Lanka			M/S	H
	Thailand		S	Pacific	H
	Timor-Leste	S	S	Pacific	H

M	Makran Subduction Zone
S	Sunda Trench
H	Heard Island Volcano
FM	Fani Maore Volcano

In line with time?

Timelines for WIO and NWIO countries

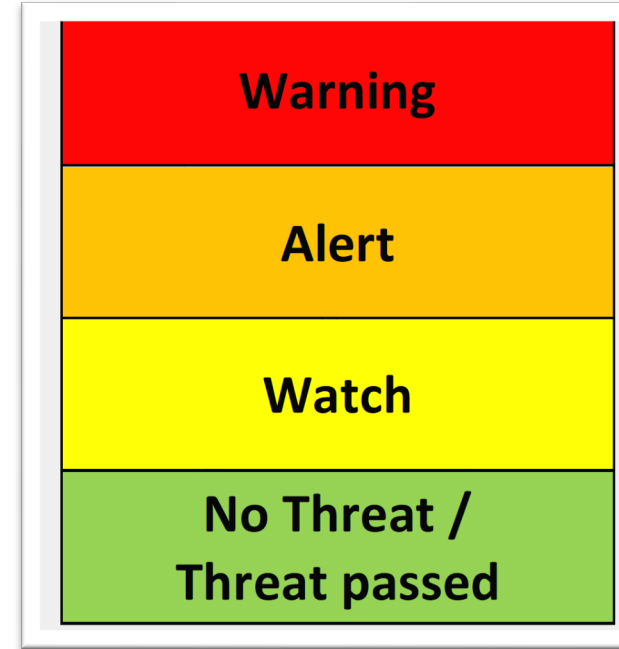
		Threat			
		Near Field ETA < 60 minutes	Regional ETA 60-180 minutes	Far Field ETA >180 Minutes	
WIO	Comoros	FM		M/S	H
	France (Réunion)			M/S	H
	France (Mayotte)	FM		M/S	H
	Kenya		FM	M/S	H
	Madagascar	FM		M/S	H
	Mauritius		FM	M/S	H
	Mozambique	FM		M/S	H
	Seychelles	FM		M/S	H
	South Africa			M/S	H
	Tanzania	FM		M/S	H
	Yemen		M	S	H
NWIO	Iran	M		S	
	Oman	M		S	H
	Pakistan	M		S	
	UAE	M		S	

M	Makran Subduction Zone
S	Sunda Trench
H	Heard Island Volcano
FM	Fani Maore Volcano

In line with time?

Important Considerations

1. TSP have different timelines for seismic and volcano induced tsunamis
2. Countries with near field threats ($ETA < 60$ minutes from all kind of sources) can not only rely on TSP information as TSP timelines do not yet fully meet the requirements for the fast response needed.
3. WIO countries, which have so far focused on far field threats from seismic sources (Sunda Trench and Makran Subduction Zone), now need to find a way how to address near field threats from volcanic sources in their surroundings. TSP information on these threats will be too late for most of the affected countries, where $ETA < 60$ minutes.



WARNING LEVELS

Tsunami Threat Levels & Response

in accordance with IOC/TOWS-WG VIII/3 March 2015 and
IOTWMS Users Guide for National Tsunami Warning Centers - Version 2.0 - 2019)

Levels of emergency public response	Threat Level	Potential Impact
People should evacuate tsunami hazard zones	3	Land inundation threat: tsunamis that can inundate coastal communities possibly causing significant damage
People should stay out of the water and away from the immediate foreshore including inlets of water	2	Tsunamis that are a marine threat may generate strong and unusual currents in coastal waters.
No immediate action is required until more information is available	1	Potential land/marine threat but are still under evaluation
No action necessary	0	No possibility of a tsunami or tsunamis that are generated but are not expected to cause damage or be a danger to people

Thresholds, Warning Levels & Color Codes

Example: Harmonized Approach in the NWIO

Oman		Pakistan		Iran		India				
as adjusted according to Country team		by PMD				Potential threat (before water level confirmation)			Confirmed threat (after water level confirmation)	
						Time > 60 min	Time ≤ 60 min			
> 3 m	Warning	> 2 m	Warning	> 2 m	Warning	--	> 2 m	Warning	> 2 m	Warning
0.5 – 2.9 m	Alert	0.5 – 1.9 m	Alert	0.5 – 2 m	Alert	> 2 m	0.5 – 2 m	Alert	0.5 – 2 m	Alert
0.2 – 0.5 m	Watch	0.2 – 0.5 m	Watch	0.2 – 0.5 m	Watch	0.5 – 2 m	0.2 – 0.5 m	Watch	0.2 – 0.5 m	Watch
< 0.2 m	No threat	not yet considered		not yet considered		not yet considered				
< 0.2 m	Threat Passed	< 0.2 m	"No threat"			0.2 – 0.5 m		Watch	< 0.2 m (T4 + 120 min)	Threat Passed

The threshold values shown refer to tsunami amplitude.

Sea level measurements

Mainshock



8 pm GMT

9 pm

10 μm

11 pm

Maximum Arrival

First Arrival

O-P

0-

O-T

 $\tau/2$

T/21440

minutes

Minimum Tsunami arrival time (trough)

Maximum Tsunami
arrival time

Amplitude

difference between a particular peak or trough of the tsunami and sea level at that time

or

half the difference between an adjacent trough and peak and can be corrected for the change of tide between that trough and peak

Source: IOTWMS TSP Service Definition Document

No threat / End of threat / All clear

Definitions

No threat

- An earthquake was felt (or recorded) but do not pose a tsunami threat

End of threat or Threat passed (or TSP Final Bulletin)

- A warning will be lifted when damaging waves have stopped coming ashore (or). It is issued when sea level readings indicate that the tsunami is below destructive levels and subsiding in most monitored locations (for > 2 h)

All clear

- After a warning is lifted, an All-Clear condition is issued by local authorities (not the NTWC) to the public when it is safe for them to return to the evacuated zones

Cancellation

- Inform NTWCs that a Notification Message previously issued was false or incorrect, and is now cancelled

Tsunami Glossary 2019, IOTWMS NTWC User Guide

Example from India and Indonesia

WARNING LEVEL, ADVICE AND SOPS

NTWC SOP - India

Threat Status	Action to be taken	Dissemination to		
WARNING	Public should be advised to move inland towards higher grounds. Vessels should move into deep Ocean	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media	WARNING	
ALERT	Public should be advised to avoid beaches and low-lying coastal areas. Vessels should move into deep Ocean	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media	ALERT	
WATCH	No immediate action is required	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Media	WATCH	
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media	THREAT PASSED	

Example of Indonesia

NTWC Warning & Advice to Local Governments

No.	Warning Level	Advice to Local Government by BMKG
1	AWAS (Major Warning)	Provincial/District/City Governments that are at “Major Warning” level are expected to pay attention to this warning and immediately guide their communities for full evacuation.
2	SIAGA (Warning)	Provincial/District/City Governments that are at “Warning” level are expected to pay attention to this warning and immediately guide their communities for evacuation.
3	WASPADA (Advisory)	Provincial/District/City Governments that are at “Advisory” level are expected to pay attention to this warning and immediately guide their communities to move away from beaches and river banks.

Source: Tsunami Early Warning Service Guidebook for InaTEWS, 2012

<https://www.gitews.de/tsunami-kit/en/E3/tool/Tsunami%20Early%20Warning%20Service%20Guidebook%20for%20InaTEWS.pdf>

Example of Indonesia

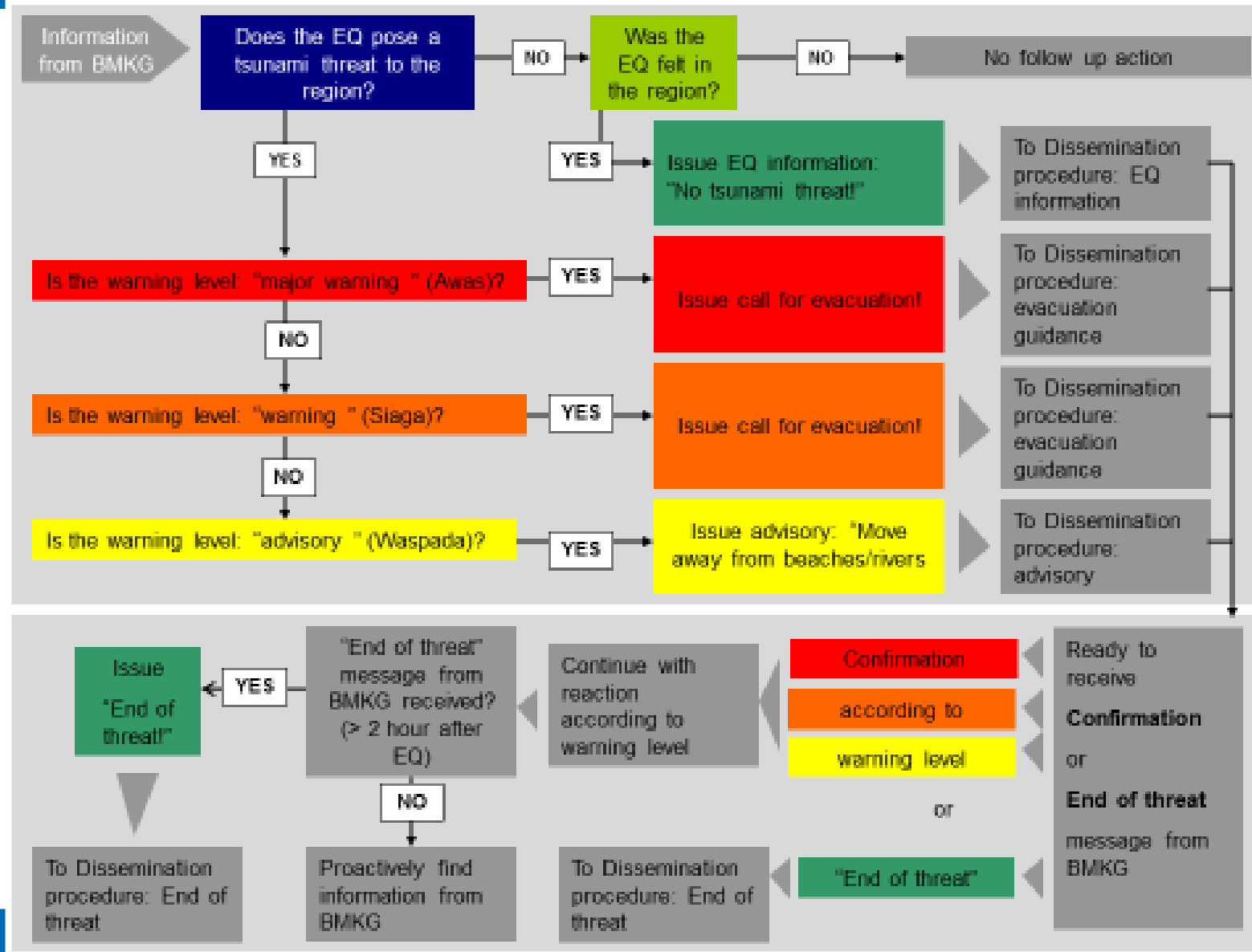
From Warning and Advice to Guidance for Communities

Warning & Advice from National Warning Centre at BMKG, Jakarta	Warning Level	Advice from BMKG to Local Government	Guidance from Local Government to Community
	MAJOR WARNING (AWAS)	Province/District/City government that are at "Major Warning" level are expected to pay attention to this warning and immediately guide their communities for full evacuation.	Call for immediate evacuation!
	WARNING (SIAGA)	Province/District/City government that are at "Warning" level are expected to pay attention to this warning and immediately guide their communities for evacuation.	
	ADVISORY (WASPADA)	Province/District/City government that are at "Advisory" level are expected to pay attention to this warning and immediately guide their communities to move away from the beach and river banks.	Advice to move away from beaches and rivers!
	EARTHQUAKE INFORMATION	Earthquake on land, earthquake with minor magnitude or too deep – no tsunami threat	No action!

Source: Tsunami Early Warning Service Guidebook for InaTEWS, 2012

<https://www.gitews.de/tsunami-kit/en/E3/tool/Tsunami%20Early%20Warning%20Service%20Guidebook%20for%20InaTEWS.pdf>

Example of Indonesia LDMO SOP

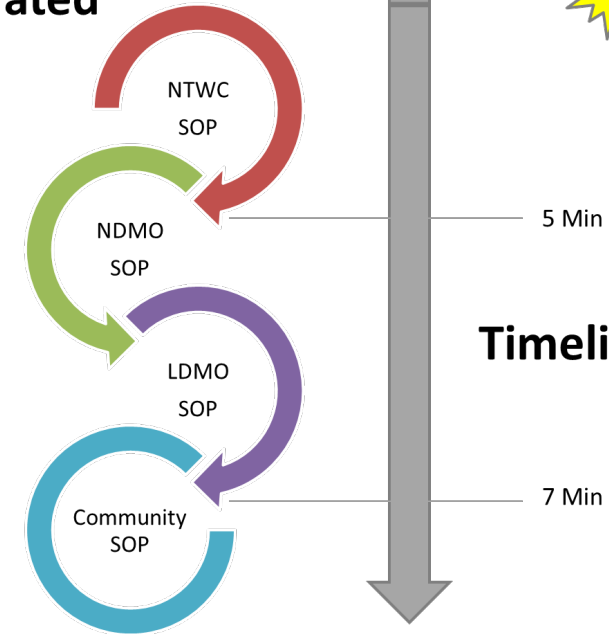


Source: Tsunami Early Warning Service
Guidebook for InaTEWS, 2012
<https://www.gitews.de/tsunami-kit/en/E3/tool/Tsunami%20Early%20Warning%20Service%20Guidebook%20for%20InaTEWS.pdf>

The importance of warning levels

1. Warning levels allows to **link threat information to institutional and public response** in a clear and transparent way
2. By agreeing on warning levels among the relevant stakeholder it allows to establish a **joint framework** which combines **tsunami warning levels** (mandate of the NTWC) with the respective **response** (mandate of the DMOs) and provides clear indication whether to **call for evacuation** (mandate usually either by the NDMO or LDMO)
3. Then, warning levels can play a **key role in the SOP development** at all levels

Integrated



CRITICAL ISSUES IN THE WARNING CHAIN

for disseminating warnings down to the community

Critical issues to have in mind...

Organization of warning chains

- Too many steps with many actors involved
- Unrealistic timelines
- Unclear roles and responsibilities
- Translation from warning to guidance

Decision making processes

- Respecting the mandates
- Decision making SOP
- Standard reaction scheme based on warning levels

Threat Status	Action to be taken	Dissemination to		
WARNING	Public should be advised to move inland towards higher grounds. Vessels should move into deep Ocean	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media	WARNING	
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WATCH	No immediate action is required	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Media	WATCH	
THREAT PASSED	All clear determination to be made by the local authorities	MoES, MHA, NDMA, NCMC, NDRF Battalions, SEOC, DEOC, Public, Media	THREAT PASSED	

Coverage at local level

- Broadcast media plays an important role, arrangements need to be strengthened
- Public alert systems (sirens) available usually only in few places
- Potential for use of new ICT (cell-broadcasting, social networks, smartphones applications)

Critical issues to have in mind...

Warning without providing guidance is not effective

- The warning and guidance might come from different institutions (NTWC, N/LDMO) which may not always interlink to each other

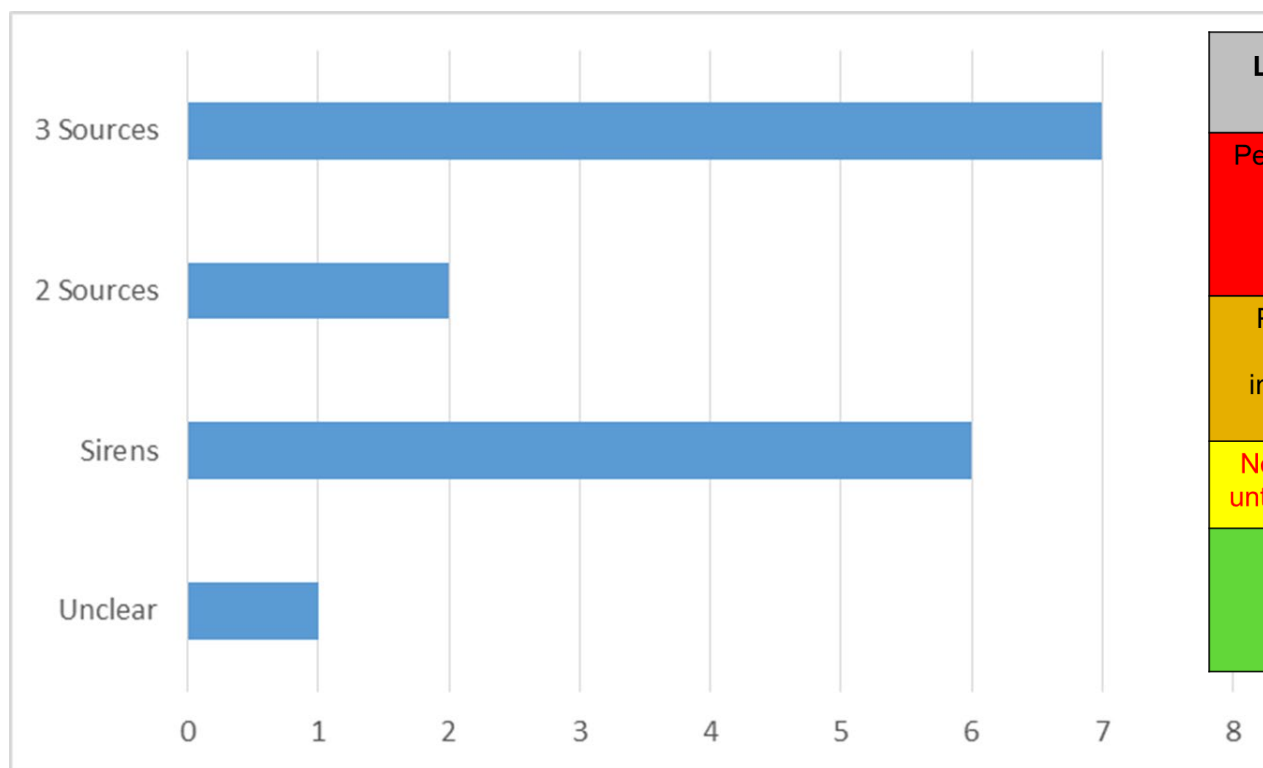
A core task in the warning chain is to decide whether to officially call for evacuation, i.e trigger public alert systems / sirens

- Assure that responsible institutions have the necessary information and capacity for timely (24/7) decision making and communicating it to the public and media

The warning chain is only as strong as its weakest link

Redundancy & Consistency of Warning Information

Does the community at risk receives the warning from multiple sources? Are the contents of messages from different sources well aligned?



Levels of emergency public response	Threat Level	Potential Impact
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No immediate action is required until more information is available	1	Potential land/marine threat but are still under evaluation
No action necessary	0	No possibility of a tsunami or tsunamis that are generated but are not expected to cause damage or be a danger to people

Sources of official warnings from EIO countries reaching out directly to the Communities at Risk (NTWC, NDMO, LDMO, Media)

Some considerations for dealing with **near-field** tsunamis

In line with the time...

Policies and procedures must be designed in a way to be executed realistically in the short time frame available

Tsunami early warning is complementary

Never wait for an official warning!

Promote self-evacuation - if long or strong, get gone!

Focus on Self-Protection

People will be on their own

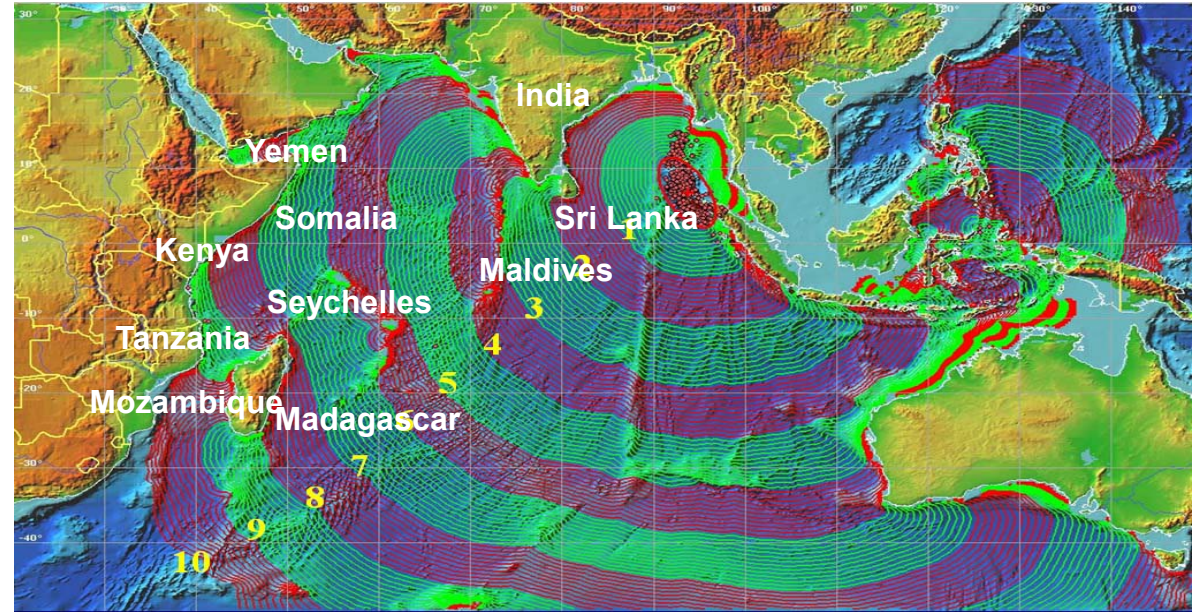
Everyone needs to know what to do during a tsunami emergency

There will be no time for discussion or lengthy instructions



Some considerations for dealing with **distant** tsunamis

In principle there is enough time for WIO countries to wait for confirmation by the TSPs that a tsunami from a distant source has actually been generated before issuing a national warning by the NTWC



Nevertheless, policies and procedures must be designed in way to be executed realistically to enable people to evacuate orderly in time

Some considerations for dealing with **distant** tsunamis

Manage public information at all times of an incident

- People will learn about a potential distant threat from different sources
- Important for the national TEWS to **be the main source of information**
- Inform people about a **possible threat** even before a national warning has been issued and that a warning will be issued if necessary
- A “**No Threat**” **message** is important once it comes clear that the incident does not pose a threat for the country
- In case a national warning has been issued, “**Final Warning**” and “**All Clear**” messages are required once the tsunami threat is over

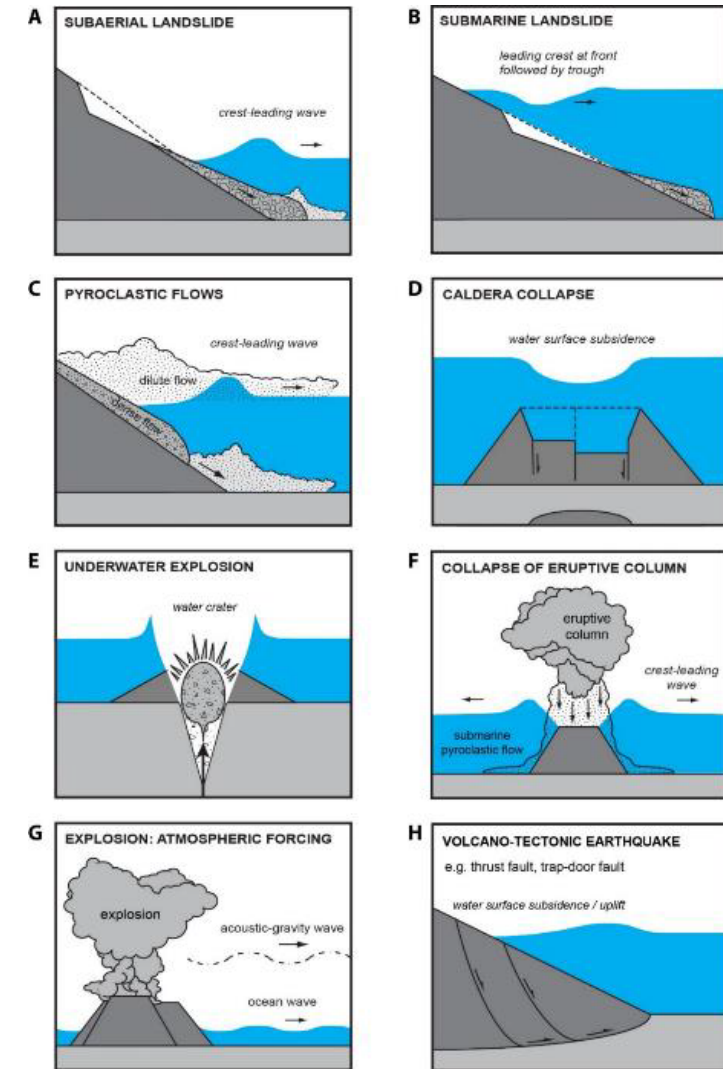
Landslide induced tsunamis

- Submarine landslides are currently **hard to observe** and **difficult to warn** for.
- Landslides causing tsunamis are often triggered by earthquakes or volcanoes
- When triggered by earthquakes they and can **amplify seismically induced tsunami waves**. They also might have different **arrival times**, as they may occur at a different location from the triggering earthquake. Additionally, they **can be triggered by much smaller earthquakes** than seismic induces tsunamis.
- The possibility of landslide-induced tsunamis should be mentioned in earthquake information and tsunami warning messages

Some considerations for dealing with **non-seismic** tsunamis

Volcanic induced tsunamis

- The vast majority of volcanic induced tsunamis occur **during an eruption** phase. They are characterized by **variable and complex source mechanisms**.
- For the time being, **warnings for volcanic induced tsunamis are limited** to a few volcanoes monitored for sea level anomalies in the near-field, or using observations with slower confirmation times more suitable for distance source threats.





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THANK YOU



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